

## Production of Whippable Nonfat Dried Milk by Homogenation

### Abstract

Homogenizing nonfat milk before drying produces a powder which on reconstitution with water can be whipped to form a stable foam useable as a dessert topping in low-fat diets. The per cent over-run produced by whipping and the stability of the resultant foam were dependent upon homogenization pressure, the total milk solids in the reconstituted material, and the stage in the process at which the milk was homogenized. Maximum foam stability and over-run were obtained by whipping for three minutes a product containing 30% total solids, prepared from powder made by drying pasteurized nonfat milk (77 C 15 sec) that had been homogenized at 281 kg/cm<sup>2</sup> before condensing. These foams had no cooked flavor, could be sweetened, and maintained their structure for more than one hour at room temperature without addition of acid or rennet.

One of the first attempts to constructively utilize the ordinarily annoying tendency of milk to foam was made by Webb (6). He published information pertaining to the stability and over-run of foams produced by whipping reconstituted nonfat dried milk. He also established that high total solids in the reconstituted milk, low temperature at whipping time, and addition of acid or fruit pulp before whipping improved foam stability. Webb further reported that high heat treatment of the milk before drying resulted in powders having superior foaming capacity on reconstitution.

We noted that some of our experimental samples of foam-spray-dried nonfat powders made from pasteurized nonfat milk containing below 0.1% of fat and homogenized at high pressure before drying, had a remarkable tendency to foam on reconstitution.

Because of the continued interest of the American public in low-fat foods that are

simple to prepare, we further explored the effect of homogenization of nonfat milk for the preparation of foam toppings. This paper reports the results.

### Materials and Methods<sup>1</sup>

The nonfat dried milks used in our work were all foam-spray-dried material made from fresh milk as described by Bell and his associates (2). Pasteurization was done by holding at 77 C for 15 sec. Homogenization was done, where desired, with a Manton-Gaulin Model 75KF3-8BS homogenizer.

One hundred-milliliter samples of the material to be investigated were placed in a Kimax one-liter graduated beaker and whipped to a foam, using a Hamilton Beach Model D household type electric beater. The amount of over-run obtained on whipping was observed from the beaker graduation marks. Foam stability was determined by transferring a sample of foam to the bottom of a 250-ml beaker, inverting the beaker in such fashion that its side wall formed a 20-degree angle with the horizontal, then noting the time at which the first drop of milk drained out of the foam. All over-run determinations and foam stability studies were done at 25 C, using solutions and equipment equilibrated to that temperature.

### Results

Fresh pasteurized nonfat milk cannot be whipped into a stable foam; it leaks fluid immediately after whipping is stopped, regardless of total solids concentration. When the nonfat milk is subjected to homogenization, foams can be formed whose stability is dependent upon the total solids content of the materials being whipped. This is demonstrated in Fig. 1. Continued whipping did not improve stability significantly beyond three minutes, as can be seen from the tendency of the stability curves to level after passing that point.

Since achievement of maximum over-run and foam stability per unit whipping time was the objective of our further development work, we present the remaining data in those terms. Fig. 2, a plot of over-run versus foam stability, though unusual in shape, adequately demonstrates that, as the pressure used to homoge-

<sup>1</sup> Received for publication September 3, 1968.

<sup>2</sup> Mention of brand or firm name does not constitute an endorsement by the Department of Agriculture over others of a similar nature not mentioned.

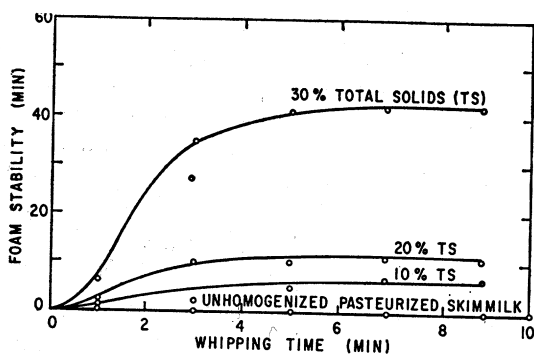


FIG. 1. Effect of whipping time on foam stability of reconstituted nonfat dried milk made from unconcentrated pasteurized skimmilk homogenized at 387 kg/cm<sup>2</sup>.

nize unconcentrated nonfat milk is increased, the most satisfactory product is obtained using 281 kg/cm<sup>2</sup> pressure. In this type of plot, most desirable whipping properties will be found in the upper right quadrant of the graph. Products having poorest whipping properties occupy the lower left quadrant.

While the stability of the foams described by data shown in Fig. 2 is relatively low, it can be improved by increasing the total solids of the homogenized material being whipped. This improvement of stability, achieved by addition of milk solids to the system, tends to depress the over-run obtained on whipping, as shown in Fig. 3. However, even with systems containing 40% total homogenized nonfat milk solids, 350% over-run can be obtained and the resultant foams can be held at room temperature for 60 min before leaking a drop of fluid, although this foam is too heavy to maintain its shape. Thirty per cent, therefore, is the optimum total solids level.

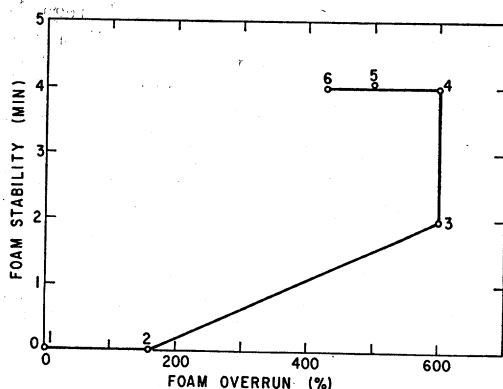


FIG. 2. Effect of homogenization of unconcentrated nonfat milk on foam stability and over-run. Whipping time, three minutes; homogenization pressure = point number  $\times$  70.3 kg/cm<sup>2</sup>.

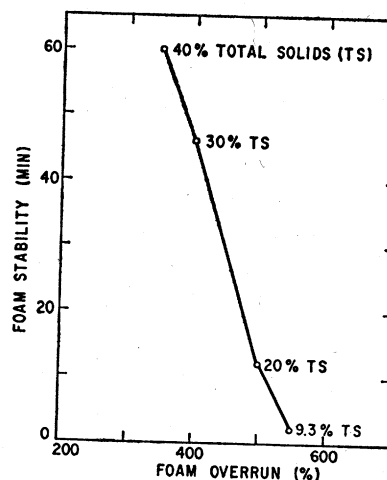


FIG. 3. Effect of total solids content of nonfat milk on foam stability and over-run. Homogenized unconcentrated at 387 kg/cm<sup>2</sup>; whipping time, three minutes.

From an economic viewpoint, it would possibly be desirable to homogenize nonfat milk after concentration. The effect of homogenizing concentrates of various total solids contents after concentration is shown in Fig. 4. Here again, we see the maximum desirable whipping properties achieved by use of 281 kg/cm<sup>2</sup> pressure during homogenization. Also, the whipping properties are improved by high total solids.

When a direct comparison is made of the whipping properties of concentrates of the same total solids concentration but homogenized equally either before or after concentration, a difference in foaming properties is noted. (See Fig. 5.) From these data, it is

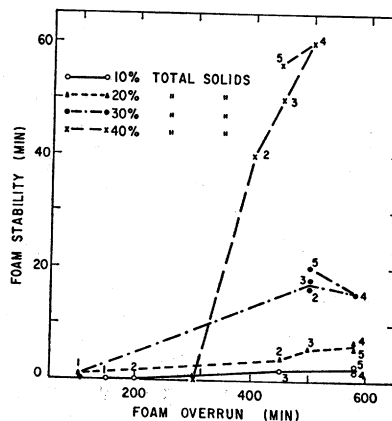


FIG. 4. Effect of homogenizing nonfat milk after concentration on foam over-run and stability. Homogenization pressure = point number  $\times$  70.3 kg/cm<sup>2</sup>.

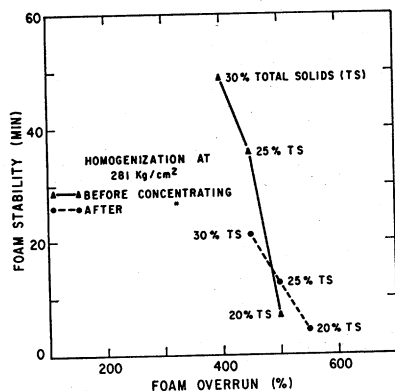


Fig. 5. Effect of homogenization-condensation sequence on foam over-run and stability.

evident that improved foam stability is best achieved by homogenizing nonfat milk before concentration.

#### Discussion

The foaming tendencies of nonfat milk can be increased by homogenization and this property persists in the concentrate even through spray drying. The foams produced by high solids concentrates of homogenized nonfat milk are light, fine-grained, and brilliantly white. Their taste is essentially bland and they have neither the density nor richness of whipped cream. However, for those interested in minimum fat intake they can serve as a satisfactory dessert topping, since they are rigid, or self-supporting (except when made up with concentrates having 40% total solids or more), and retain water without leaking for a considerable time.

Our rather simple procedure to determine the stability of foams produced by various products is a minor variant of procedures used in pioneer studies of the properties of whipped cream (3). The water retention capacity of the foam relates directly to the stability or durability of its structure.

The best over-runs we observed with the homogenized nonfat products were more than double those reported for heavy whipping cream (3). The factors influencing the over-run of fat-containing products are rather complex relating to acidity, fat content, temperature of whipping, and aging of the cream (1).

The factors responsible for the whipping properties of nonfat milk have been less widely studied. While it has been commonly accepted that homogenization has no effect on the nonfat constituents of milk, our work makes this position seemingly untenable. Moreover, at least

30% of the milk phosphatides are found in the nonfat fraction (4). The structures containing these materials have never been well defined and it is possible that the shearing action encountered in the homogenizer may disrupt microsomal structures (5) with release of surface-active materials. Rupture of casein micelles into smaller, more surface-active particles is another possibility.

Regardless of mechanisms, homogenization of nonfat milk plus concentration produces material which can be readily whipped into stable foams. It has been our experience that the rate at which these foams can be obtained depends upon construction of the beater.

Foam-spray-drying the concentrates made from homogenized nonfat milk had no effect on the foaming properties of the milk solids. These powders, when reconstituted properly, had the same whipping properties as the concentrates.

Foams produced by whipping samples of instantized nonfat dried milks obtained in local markets were observed to be less stable than those we produced from homogenized nonfat milk. These foams were all relatively weak and tended to leak fluid in 10 to 12 min. In contrast, the foams we have observed that are made from nonfat milk pasteurized at 77 C for 15 sec, then homogenized at 281 kg/cm<sup>2</sup>, were comparatively stable. When made into powder, reconstituted to 30% total solids and whipped for three minutes, the foams had 400% over-run and could be held for about 50 min at 25 C before leaking a drop of fluid.

We did not make a detailed study of the sugar-carrying capacity of the foams, but casual observations indicated that they could be sweetened and flavored much like whipped cream. The foams had no heat-setting properties and were quickly destroyed above 100 C.

We therefore conclude that the homogenization of low-heat pasteurized nonfat milk before concentration and spray drying will produce a powder which, if reconstituted to 30% total solids, can be whipped into stable foams suitable for dessert topping without cold water, cold utensils, and the addition of fruit pulp or lemon juice.

The physico-chemical changes in milk caused by homogenization and reflected in its improved whipping properties are being investigated.

#### References

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